

FORM PTO-1390 (REV 10-2000)		U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE		ATTORNEY'S DOCKET NUMBER
				34691/234885
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371				U.S. APPLICATION NO. (If known, see 37 C.F.R. 1.5)
INTERNATIONAL APPLICATION NO PCT/DE99/04070		INTERNATIONAL FILING DATE December 21, 1999		09/868716
PRIORITY DATE CLAIMED December 21, 1998				
TITLE OF INVENTION METHOD AND DEVICE FOR OBJECT RECOGNITION				
APPLICANT(S) FOR DO/EO/US Jurgen Beyerer; Mohammed Ali Seiraffi				
Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:				
<p>1. <input checked="" type="checkbox"/> This is a <b>FIRST</b> submission of items concerning a filing under 35 U.S.C. 371.</p> <p>2. <input type="checkbox"/> This is a <b>SECOND</b> or <b>SUBSEQUENT</b> submission of items concerning a filing under 35 U.S.C. 371.</p> <p>3. <input checked="" type="checkbox"/> This is an express request to promptly begin national examination procedures (35 U.S.C. 371(f)).</p> <p>4. <input type="checkbox"/> The US has been elected by the expiration of 19 months from the priority date (PCT Article 31).</p> <p>5. <input checked="" type="checkbox"/> A copy of the International Application as filed (35 U.S.C. 371(c)(2))        a. <input checked="" type="checkbox"/> is attached hereto (required only if not communicated by the International Bureau).        b. <input type="checkbox"/> has been communicated by the International Bureau.        c. <input type="checkbox"/> is not required, as the application was filed in the United States Receiving Office (RO/US).</p> <p>6. <input checked="" type="checkbox"/> A English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).</p> <p>7. <input type="checkbox"/> Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))        a. <input type="checkbox"/> are attached hereto (required only if not communicated by the International Bureau).        b. <input type="checkbox"/> have been communicated by the International Bureau.        c. <input type="checkbox"/> have not been made; however, the time limit for making such amendments has NOT expired.        d. <input type="checkbox"/> have not been made and will not be made.</p> <p>8. <input type="checkbox"/> An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).</p> <p>9. <input checked="" type="checkbox"/> An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).</p> <p>10. <input type="checkbox"/> An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).</p>				
Items 11. To 16. Below concern other document(s) or information included:				
<p>11. <input checked="" type="checkbox"/> An Information Disclosure Statement under 37 C.F.R. 1.97 and 1.98.</p> <p>12. <input checked="" type="checkbox"/> An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.</p> <p>13. <input checked="" type="checkbox"/> A <b>FIRST</b> preliminary amendment.  <input type="checkbox"/> A <b>SECOND</b> or <b>SUBSEQUENT</b> preliminary amendment.</p> <p>14. <input type="checkbox"/> A substitute specification.</p> <p>15. <input type="checkbox"/> A change of power of attorney and/or address letter.</p> <p>16. <input checked="" type="checkbox"/> Other items or information: 2 sheets of formal drawings 7 prior art references; copy of Search Report</p>				

U.S. APPLICATION NO. (known, see 37 CFR 1.50) <b>09/868716</b>		INTERNATIONAL APPLICATION NO PCT/DE99/04070	ATTORNEY'S DOCKET NUMBER 34691/234885
17. <input checked="" type="checkbox"/> The following fees are submitted:		CALCULATIONS	PTO USE ONLY
<b>Basic National Fee (37 CFR 1.492(a)(1)-(5)):</b> Neither international preliminary examination fee (37 CFR 1.482) nor International search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO		<b>\$1,000.00</b>	
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO		<b>\$860.00</b>	
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search (37 CFR 1.445(a)(2)) paid to USPTO		<b>\$710.00</b>	
International preliminary examination fee (37 CFR 1.482) paid to USPTO But all claims did not satisfy provisions of PCT Article 33(1)-(4)		<b>\$690.00</b>	
International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4)		<b>\$ 100.00</b>	
<b>ENTER APPROPRIATE BASIC FEE AMOUNT</b> =		<b>\$ 860.00</b>	
<b>Surcharge of \$130.00 for furnishing the oath or declaration later than</b> <input type="checkbox"/> 20 <input type="checkbox"/> 30 months <b>from the earliest claimed priority date (37 CFR 1.492(e)).</b>		<b>\$</b>	
<b>CLAIMS</b> Total Claims 15 -20 = 0      X \$18.00 \$ 0.00 Independent Claims 2 - 3 = 0      X \$80.00 \$ 0.00 <b>MULTIPLE DEPENDENT CLAIM(S) (if applicable)</b> + \$270.00 \$ 860.00			
<b>TOTAL OF ABOVE CALCULATIONS</b> =		<b>\$ 860.00</b>	
<b>Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by one-half.</b>		<b>\$</b>	
<b>SUBTOTAL</b> =		<b>\$ 860.00</b>	
<b>Processing fee of \$130.00 for furnishing the English translation later than</b> <input type="checkbox"/> 20 <input type="checkbox"/> 30 months <b>from the earliest claimed priority date (37 CFR 1.492(f)).</b>		<b>\$</b>	
<b>TOTAL NATIONAL FEE</b> =		<b>\$ 860.00</b>	
<b>Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). \$40.00 per property</b> +		<b>\$ 40.00</b>	
<b>TOTAL FEES ENCLOSED</b> =		<b>\$ 900.00</b>	
		Amount to be Refunded	\$
		Charged	\$
a. <input checked="" type="checkbox"/>	A check in the amount of \$ 900.00 to cover the above fees is enclosed.		
b. <input type="checkbox"/>	Please charge my Deposit Account No. 16-0605 in the amount of \$ to cover the above fees. A duplicate copy of this sheet is enclosed.		
c. <input checked="" type="checkbox"/>	The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 16-0605.		
Note: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137 (a) or (b)) must be filed and granted to restore the application to pending status.			
<b>SEND ALL CORRESPONDENCE TO:</b> Charles B. Elderkin <i>Charles B. Elderkin</i>		<b>"Express Mail" Mailing Label Number EL836092972US</b> Date of Deposit: June 20, 2001	
<b>SIGNATURE</b> <b>REGISTRATION NUMBER 24,357</b> <b>ALSTON &amp; BIRD LLP</b> Bank of America Plaza 101 South Tryon Street, Suite 4000 Charlotte, NC 28280-4000 Tel Charlotte Office (704) 444-1000 Fax Charlotte Office (704) 444-1111 <b>Customer Number 000826</b>		I hereby certify that this paper or fee is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1.10 on the date indicated above and is addressed to BOX PCT, Attn: DO/US PTO, Commissioner for Patents, Washington, DC 20231. <i>Joyce D. Smith</i> Joyce D. Smith	

09/868716

JC18 Rec'd PCT/PTO 20 JUN 2001

IN THE UNITED STATES DESIGNATED OFFICE (DO/US)

In re: Beyerer et al.

Attn: DO/US

International Appl. No.: PCT/DE99/04070

International Filing Date: December 21, 1999

For: METHOD AND DEVICE FOR OBJECT RECOGNITION

June 20, 2001

Box PCT  
Commissioner for Patents  
Washington, DC 20231

**PRELIMINARY AMENDMENT**

Sir:

Please amend the above-identified application as follows:

In The Claims:

Please cancel Claims 1-29 without prejudice, and add the following new Claims 30-44.

30. (New) A method of detecting defects on workpieces comprising the steps of

illuminating the workpiece by at least two light sources from different directions,

recording by means of a camera the illuminated workpiece and the shadows resulting from the illumination, and processing the recorded data in a computer.

31. (New) The method of Claim 30, wherein the camera is arranged at a fixed location.

32. (New) The method of Claim 30, wherein the camera includes a lens and wherein the camera is encased at least in the region of the lens.

33. (New) The method of Claim 30, wherein the processing step includes exchanging signals between the computer and a stored program control.

34. (New) The method of Claim 30, wherein the recorded

data comprises an image, and comprising the further step of performing a qualitative or quantitative image evaluation on the recorded image.

35. (New) The method of Claim 30, wherein the processing step includes processing the recorded image by comparing the recorded image with a record of reference data.

36. (New) The method of Claim 35, wherein the comparing step includes a coarse correlation with the recorded data.

37. (New) The method of Claim 35, wherein the recording step includes recording at least two images which are processed in the processing step.

38. (New) The method of Claim 37, wherein the image processing step includes a position correction.

39. (New) The method of Claim 38, wherein the position correction includes recording reference marks.

40. (New) The method of Claim 39, wherein the reference marks are lines and/or dots on a base.

41. (New) The method of Claim 35 wherein the processing step comprises a brightness adjustment for adapting the gray-scale values of the image.

42. (New) The method of Claim 35, wherein the image processing step comprises a defect detection.

43. (New) An apparatus for detecting defects on workpieces comprising  
at least two light sources for illuminating the workpiece from different directions,  
a camera for recording the illuminated workpiece and the shadows resulting from the illumination, and

a computer for processing the data received from the camera.

44. (New) The apparatus of Claim 43 further comprising a stored program control which is connected to the computer.

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REMARKS

The above amendments are made to more clearly define the invention under United States practice. Please enter this amendment prior to calculation of the filing fee.

Respectfully submitted,



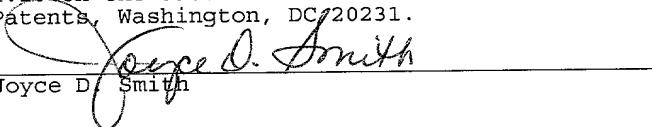
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Joyce D. Smith

21/07/05

09/868716  
JC18 Rec'd PCT/PTO 20 JUN 2001

METHOD AND DEVICE FOR OBJECT RECOGNITION

The invention relates to a method of recognizing objects, in particular detecting defects on workpieces, preferably on shot cores or core packets, 5 wherein the object is illuminated by a light source and recorded or detected by means of a camera, and wherein the data obtained from the recording are processed and, if need be, stored by means of a computer.

Furthermore, the invention relates to an 10 apparatus for recognizing objects, in particular for applying the method according to the invention.

In generic terms, the invention quite generally relates to a method for recognizing objects or detecting defects on workpieces. Quite particularly, this method 15 is suited for detecting defects on shot cores or core packets. To this extent, the invention also relates, among other things, to the field of foundry practice.

For casting mold parts of any kind, foundry cores or molds are made in most cases in separate pieces, 20 combined, and joined to a casting mold or a core packet. These core packets are then filled with a molten metal for making, for example, a metallic work piece. In the series production, the core packets to be filled with the molten metal pass, one after the other, through a 25 production line.

In this connection, it is particularly important that the workpieces cast in the core packets require an extremely long cooling phase, which often extends over several hours. Only after this cooling 30 phase, is it possible to inspect the cast workpiece or part. Consequently, it is possible to find out only several hours after the casting, and thus likewise only

several hours after the core shooting, whether the part cast in the core packet is indeed free of defects.

Should a defective core have been used, it would be possible to detect resultant rejects only hours 5 after making the core. Should it in turn be a systematic, for example, a recurrent defect on the core because of a defect on the tool, rejects would be produced for hours before the defect is identified on the cast part. As previously mentioned, the defective cores 10 responsible for these rejects could originate not only from defects in the tool of the core shooting machine, but also from direct damage to the cores during their handling, transportation, or assembly. In any event, it is not justifiable to be able to detect defects and thus 15 rejects only after completing the casting operation, or during the inspection of the cast parts that have already cooled.

Moreover, damage to mold parts and/or tools may occur not only in the immediate vicinity of the shooting 20 device, but rather also in any handling of the mold part and/or tool, during transportation, in the machining of the mold parts, during the cleaning of the tools, and in particular also during the assembly of the mold parts to whatever shape of a mold packet.

25 Core and shell shooting machines of the above-described kind have been known from practice for many decades. For example, one may refer to DE 31 48 461 C1, which discloses a core and shell shooting machine as made by Applicant.

30 Likewise, DE 44 34 798 A1 discloses a core and shell shooting machine, which is provided with at least one visual inspection of the tool. Last but not least, the visual control as addressed in DE 44 34 798 A1 is not practicable, inasmuch as it is not possible to observe

the tool constantly within the scope of a fully automatic production. For a visual inspection, a skilled worker would have to observe the tool constantly, i.e., after each shooting operation. Even if one performed such a 5 visual observation or inspection, the fate of an ejected core that is to be transported, machined, or assembled to a packet, would be left fully open, inasmuch as defects or damage may also occur during the handling or machining of the cores, during the transfer of the cores, or even 10 during the assembly of the cores to packets.

DE 195 34 984 C1 already discloses a generic method, wherein the mold part or the core is measured, among other things, by a noncontacting technique even after its removal from the core shooting machine. This 15 occurs in an advantageous manner by means of a camera, which requires in this instance an adequate illumination. Concealed regions or undercuts can be inspected by this kind of method only, when either a plurality of cameras are used for the image recording, and thus likewise for 20 detecting defects, or when a camera is moved relative to the location of the object or core being examined. Both variants require a considerable expenditure for apparatus, and therefore are problematic for cost reasons alone. Furthermore, the arrangement of a plurality of 25 cameras interferes with the direct surroundings of the particular core, and thus with the manipulators being used in this region.

It is therefore an object of the present invention to improve and further develop a method of the 30 generic kind as well as a corresponding apparatus for object recognition, in particular for detecting defects on workpieces, preferably on shot cores or core packets in such a manner that they enable an adequately satisfactory object recognition and defect detection with

the least possible expenditure for apparatus or construction.

The method of the present invention for recognizing objects accomplishes the foregoing object by 5 the characterizing steps of claim 1.

Accordingly, a generic method of the above-described kind is characterized in that the object is illuminated by at least two light sources from different directions or angles, and that the camera records the 10 object and the shadows resulting from the illumination, for example, on the object or a base. In this process, the different light sources may be switched on one after the other with respect to time (time division multiplex), or -- in the case of a continuous operation of all or 15 individual light sources -- they may be of a different color (color division multiplex, wavelength division multiplex). Furthermore, polarization multiplexes are possible with a correspondingly polarized light. The shadows may form on the object itself, on a base, a wall, 20 or a screen, or the like by a corresponding arrangement of the light sources and projections resulting therefrom.

In accordance with the invention, it has been recognized that it will also be possible to detect with a single camera irregularly shaped objects, for example, 25 objects with undercuts, niches, cutouts, etc., as regards possible defects, when a very special illumination is provided. Deviating from previously known methods of the kind under discussion, one uses for illuminating the object being examined at least two light sources adapted 30 for sequential and color differentiation. The two light sources illuminate the object from different directions or angles -- one after the other or in groups -- namely according to the geometry of the particular object. According to the arrangement of the light source relative

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to the particular object, a shadow of a part of the object is projected onto the base or onto other parts of the object, so that the object can be "extended" or "spread" by means of a shadow cast. In other words, the  
5 skillful arrangement of the light sources permits projecting regions that are otherwise not recognizable with a single camera, from their "concealed" position, and recording same as quasi additional image information supplementing the contours of the object. Thus, it is  
10 possible to perform a very satisfactory examination of critical regions, which are especially susceptible to possible defects, and to even enlarge them by a suitable projection for purposes of such an -- optical -- examination, thereby promoting in turn a satisfactory  
15 detection.

In a quite particularly advantageous manner, the illumination or the light sources are switchable, for example by electronic means or by means of mechanical shutters. It is likewise possible to use for this  
20 purpose tubular fluorescent lamps without electrodes.

The illumination selected in accordance with the invention is insensitive to vibrations. More specifically, vibrations will barely affect the illumination, since the object is illuminated by a very  
25 wide light cone. However, the camera records quasi point by point, and insofar it can over and above be miniaturized.

In accordance with the invention, 3-D image data are used for detecting defects, namely on the basis  
30 of the illumination of the object concretely claimed herein.

In an advantageous manner, the object is illuminated from different directions or angles by a plurality of light sources, preferably three to five.

For each direction of illumination, separate image data are recorded by time or by color division multiplex techniques. However, at this point, it should be remarked that the number of required light sources 5 depends on the complexity of the particular object. In the case of simple geometries, one will do with less light sources than in the case of complex geometries.

As previously mentioned, a single camera is used for recording. In so doing, recordings successively 10 made of the same object occur from a predetermined position. In this connection, it is quite possible that different recordings are made under differently illuminated conditions for purposes of successively detecting different regions of the object via its shadow 15 cast. In any event, the camera is stationarily arranged, so that insofar an adequate protection of the camera is realizable even in a dirty surrounding or damaging atmosphere.

In this connection, it will be of further 20 advantage, when the camera records the object from above, the front, or from other directions, always at the same angle with the object. As previously mentioned, the camera could be encased at least in the region of its lens, to be able to effectively avoid damage to the 25 camera or its sensitive lens.

Basically, the casing of the camera could be closed, and would be opened -- in the region of its lens -- only for recording pictures. This would create an optical protection of the camera.

30 An essential component of an apparatus for operating the method of the invention is a computer, which is used on the one hand for controlling the illumination and camera, and the other hand for processing, or editing, and finally storing the obtained

data. The computer may be a commercially available PC with the most up-to-date processor engineering and an adequate base memory.

Naturally, the meaning and purpose of the  
5 method according to the invention is less the mere  
detection of defects, but rather the making available of  
control data for the production process, such as, for  
example, core shooting. Thus, it would be possible to  
effectively avoid in the case of detecting a "defective  
10 part", that, for example, a defective core reaches  
assembly, and that by its presence the entire core packet  
qualifies as a "defective part." To this extent, it will  
be of special advantage, when the computer communicates  
with a stored program control (SPC), wherein process  
15 signals and result signals are exchanged between the  
computer and the stored program control. A process  
control may occur with obtained and processed data, as  
well as with edited data.

In a quite especially advantageous manner, a  
20 qualitative or quantitative image processing occurs on  
the recorded images or respective data. Basically in  
this instance, the recordings of the particular objects  
are compared with a reference image. This reference  
image is computed from a reference data record, which  
25 consists of n images of workpieces classified as  
"satisfactory." The reference image corresponds to the  
statistical mean value of the individual images of the  
data record. This procedure allows to lessen the  
influence of the process-inherent variation bandwidth of  
30 satisfactory parts in the computation of the reference  
image. At the same time, it is possible to use the  
extent of the variation bandwidth within the quality  
class to determine in a suitable manner the threshold  
values in the subsequent detection of defects for

purposes of avoiding a too high probability of false alarms.

Finally, a variance comparison occurs. For purposes of this comparison, it would be possible to 5 prepare a delta frame, which shows no structures in the ideal case, for example, which is entirely filled in black. In such a case, there would be a total match between the test image and the reference image.

Concretely, the image processing could comprise 10 a coarse correlation, namely a rough comparison with the data of the reference image, or with limit values that are preferably predetermined as gray-scale values. These limit values could be made variable, i.e., predetermined by the user. Depending on the object, it 15 would furthermore be possible to record at least two images, which are added or subtracted from each other for further processing.

In a further advantageous manner, the image processing comprises an automatic position correction, 20 which compensates, vis-a-vis the reference data, possible translational and rotational position inaccuracies of the object being actually examined. This allows to achieve a clear increase of the sensitivity of the system to the searched defects. The position correction may occur not 25 only with reference to fixed marks on the workpiece itself, but also alone with reference to significant object structures by means of a correlation technique.

Furthermore, the image processing could also 30 comprise a brightness adjustment for adapting the gray-scale values of the recording. This would take account of the situation that identical objects may reflect differently strong, which results in different measured values. In this process, system-immanent defects are also compensated.

As previously mentioned, the image processing could furthermore comprise a subtraction with filtering functions, if need arises. This subtraction is used for strengthening and highlighting the searched defects. The 5 filtering functions are used for lessening interferences with obtained data, provided this is possible on the basis of the object. Finally, the image processing comprises a defect detection and edited or processed data in accordance with the foregoing description. Within the 10 scope of such a defect detection, it will be of further advantage, when the detection sensitivity to a defect appearing on the object is freely definable with reference to a predetermined threshold value. To this end, it is possible to predetermine a limit value for 15 distinguishing between the defective and the satisfactory part.

In a further advantageous manner, the data of an image recording are reduced, in that one realizes a special ROI handling, namely that one continues to 20 process only data of regions of interest (ROI). In this instance, other data are of no interest.

Concretely, predetermined regions of the recorded image could be adapted for extraction or elimination. For the extraction and/or elimination, it 25 would again be possible to predetermine threshold values or gray-scales values corresponding to the threshold values. In this process, the regions of interest can be easily marked for interactive processing via a monitor. Regions prone to defects or damage may be examined with 30 very special attention. In this process, it is possible to reduce the data quantity as a whole. An individual parameterization of the individual regions of interest (ROI) leads to a further increase in the detection performance.

The apparatus of the present invention accomplishes the above-described object by the characterizing features of claim 25. Accordingly, a generic apparatus is characterized in that for 5 illuminating the object, at least two light sources are provided, which illuminate the object from different directions or angles, and that the camera is used for recording the object and the shadows forming on a base as a result of the illumination. For purposes of avoiding 10 repetitions the description of the method according to the invention is herewith incorporated by reference.

There exist various possibilities of improving and further developing the teaching of the present invention in an advantageous manner. To this end, one 15 may refer on the one hand to the dependent claims, as well as the subclaims, and on the other hand to the following description of an embodiment of the invention with reference to the drawing. In conjunction with the preferred embodiment of the invention with reference to 20 the drawing, generally preferred improvements and further developments of the teaching are also described in greater detail. In the drawing:

Figure 1 is a schematic view of an apparatus according to the invention for object recognition, the 25 apparatus being a device for detecting defects on shot cores; and

Figure 2 is a schematic view of the mode of operation of the apparatus according to the invention.

The embodiment shown in Figure 1 is an 30 apparatus for detecting defects on shot cores 1. In the illustration, two cores 1 are placed on a base 2, which may be a pallet for transportation.

The apparatus comprises a camera 3 and two light sources 4, which illuminate cores 1 from different

directions or angles, so that the camera 3 detects not only cores 1 in accordance with their contours, but also shadows caused by light sources 4.

As shown in Figure 2, the camera 3 and light sources 4 are used for recording the images of core 1. In this connection, the camera 3 and likewise the light source 4 may be controlled via a processor.

Specifically, in the illustrated embodiment, a PC 5 is provided, which receives images 7 that are taken by camera 3. The embodiment shown in Figure 2 further includes a process control by means of a stored program control (SPC) 6. The stored program control (SPC) 6 communicates with PC 5, i.e., it transmits process signals and result signals 8.

In addition, it should be remarked that a more or less skillful arrangement of light source 4 results in a corresponding shadow of the object or core 1. The length of the shadow supplies data with respect to the z-axis. A concealed region on the object can thus be exactly projected therefrom, namely via its shadow. An examination of this region is possible, even when camera 3 is arranged in an actually unsuited position relative thereto. According to the projection, it is also possible to perform from the angle of view of the camera 3 an indirect inspection of certain regions of the object, which are not directly viewable by the camera 3.

On the monitor of PC 5 it is possible to realize different displays or ways of display. It would be possible to set up a plurality of user planes. For different core types, an automatic program change could be provided for purposes of minimizing changeover times in terms of electronic data processing.

Furthermore, it is possible that the PC 5 is connected online with a computer of the service or the

manufacturing company of the entire system. In this respect, it would be possible to perform a remote maintenance.

Furthermore, it is essential that the 5 previously described systematic procedure of the image analysis furnish a high flexibility of detection or evaluation. Any desired image manipulations as well as a reduction of the required data are possible.

Finally, it should be remarked that the stored 10 program control (SPC) 6 could supply to PC 5 both a starting signal and signals relating to an automatic program change. From the PC, the status or data relating to measuring results are supplied to SPC 6. To this extent, it would be possible to use the SPC 6 for direct 15 process controls within the scope of a primary production process.

Lastly, it should be expressly remarked that the above-described embodiment serves only for describing in greater detail the claimed teaching, without however 20 limiting same to the embodiment.

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## C L A I M S

1. Method of recognizing objects, in particular detecting defects on workpieces, preferably on 5 shot cores (1) or core packets, wherein the object is illuminated by a light source (4) and recorded or detected by means of a camera (3), and wherein the data obtained from the recording are processed and, if need be, stored by means of a computer,

10 2. **characterized in** that the object is illuminated by at least two light sources (4) from different directions or angles, and that the camera records the object and the shadows resulting from the illumination.

15 3. Method of claim 1, characterized in that the object is illuminated from different directions or angles by a plurality of light sources (4), preferably three to five.

20 4. Method of claim 3, characterized in that the camera (3) in use for recording the object performs all recordings from a predetermined position.

25 5. Method of one of claims 1-4, characterized in that the camera (3) is stationarily arranged.

30 6. Method of one of claims 1-5, characterized in that the camera (3) is encased at least in the region of the lens.

7. Method of claim 6, characterized in that for recording images, the casing of the camera (3) is opened in the region of the lens.

5 8. Method of one of claims 1-7, characterized in that a PC (5) is used as computer.

9. Method of one of claims 1-8, characterized in that process signals and result signals (8) are  
10 exchanged between the computer and a stored program control (SPC) (6).

10. Method of one of claims 1-9, characterized in that a qualitative or quantitative image evaluation  
15 occurs on the recorded images (7) or on the respective data.

11. Method of one of claims 1-10, characterized in that within the scope of data processing, the recorded images are compared with a reference image or a record of reference data.

12. Method of claim 11, characterized in that a variance comparison is conducted.

25

13. Method of one of claims 10-12, characterized in that the image processing comprises a coarse correlation, namely a rough comparison with the data of the reference image (reference data).

30

14. Method of one of claims 10-13, characterized in that at least two images (7) are recorded, which are supplied to a further processing.

15. Method of one of claims 10-14,  
characterized in that the image processing comprises a  
position correction.

5 16. Method of claim 15, characterized in that  
for correcting the position of the recorded image (7)  
reference marks are recorded.

10 17. Method of claim 16, characterized in that  
the reference marks are lines and/or dots on a base (2).

15 18. Method of one of claims 10-17,  
characterized in that the image processing comprises a  
brightness adjustment for adapting the gray-scale values  
of the image.

19. Method of one of claims 1-18,  
characterized in that the image processing comprises a  
subtraction with filtering functions, if need arises.

20 20. Method of one of claims 10-19,  
characterized in that the image processing comprises a  
defect detection.

25 21. Method of claim 20, characterized in that  
a defect on the object is definable with reference to  
predeterminable parameters.

30 22. Method of one of claims 1-21,  
characterized in that predeterminable regions of the  
recorded image can be extracted.

23. Method of one of claims 1-22, characterized in that disturbing regions of the recorded image (7) can be eliminated.

5 24. Method of one of claims 22 or 23, characterized in that for the extraction and/or elimination, it is possible to predetermine threshold values or gray-scale values corresponding to the threshold values, and that same are preferably  
10 automatically definable.

25. Apparatus for recognizing objects, in particular for detecting defects on workpieces, preferably on shot cores (1) or core packets, wherein the  
15 object is illuminated by a light source (4) and recorded or detected by means of a camera (3), and wherein the data obtained from the recording are processed and, if need be, stored by means of a computer, in particular for applying a method of one of claims 1-24,  
20 **characterized in** that for illuminating the object, at least two light sources (4) are provided, which illuminate the object from different directions or angles, and that the camera (3) is used for recording the object and the shadows resulting from the illumination.

25  
26. Apparatus of claim 25, characterized in that a plurality of light sources, preferably three to five light sources (4) are provided, which illuminate the object from different directions or angles.

30 27. Apparatus of one of claims 25 or 26, characterized in that the camera is encased at least in the region of its lens and can be opened in the region of its lens for recording the images.

28. Apparatus of one of claims 25-27, characterized in that a PC (5) is used as computer.

5                   29. Apparatus of one of claims 25-28,  
characterized in that the computer connects to a stored  
program control (SPC) (6).

**ABSTRACT**

A method and an apparatus for object  
recognition, in particular defect detection on  
5 workpieces, such as shot cores (1) or core packets,  
wherein the object is illuminated by a light source (4)  
and recorded and detected by means of a camera (3), and  
wherein the data obtained from the recording are  
processed or, if need be, stored by means of a computer.  
10 The object is illuminated by a least two light sources  
(4) from different directions or angles, and the camera  
(3) records the object and the shadows resulting from the  
illumination.

15 #4484468v1

TOP SECRET//DECODE

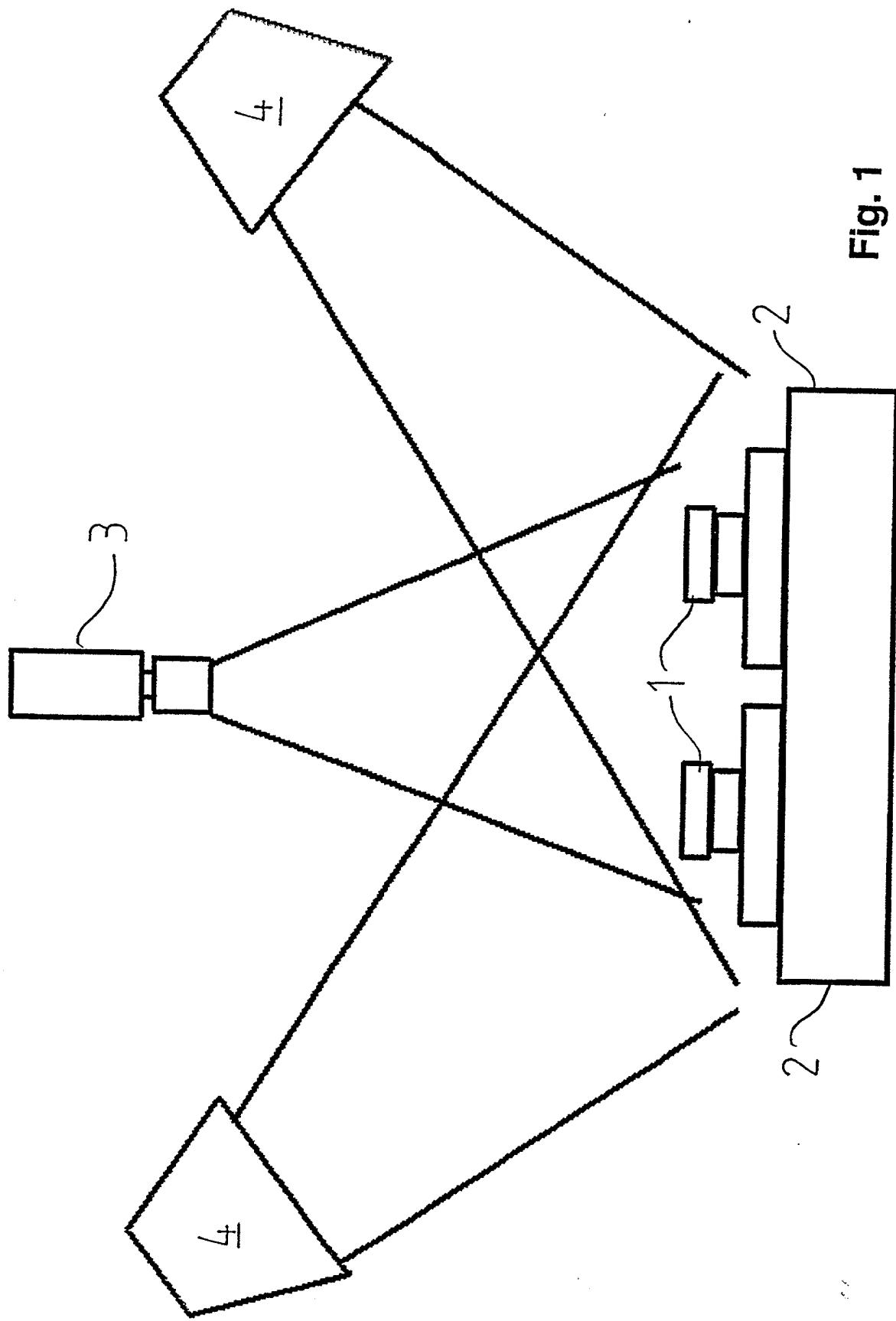


Fig. 1

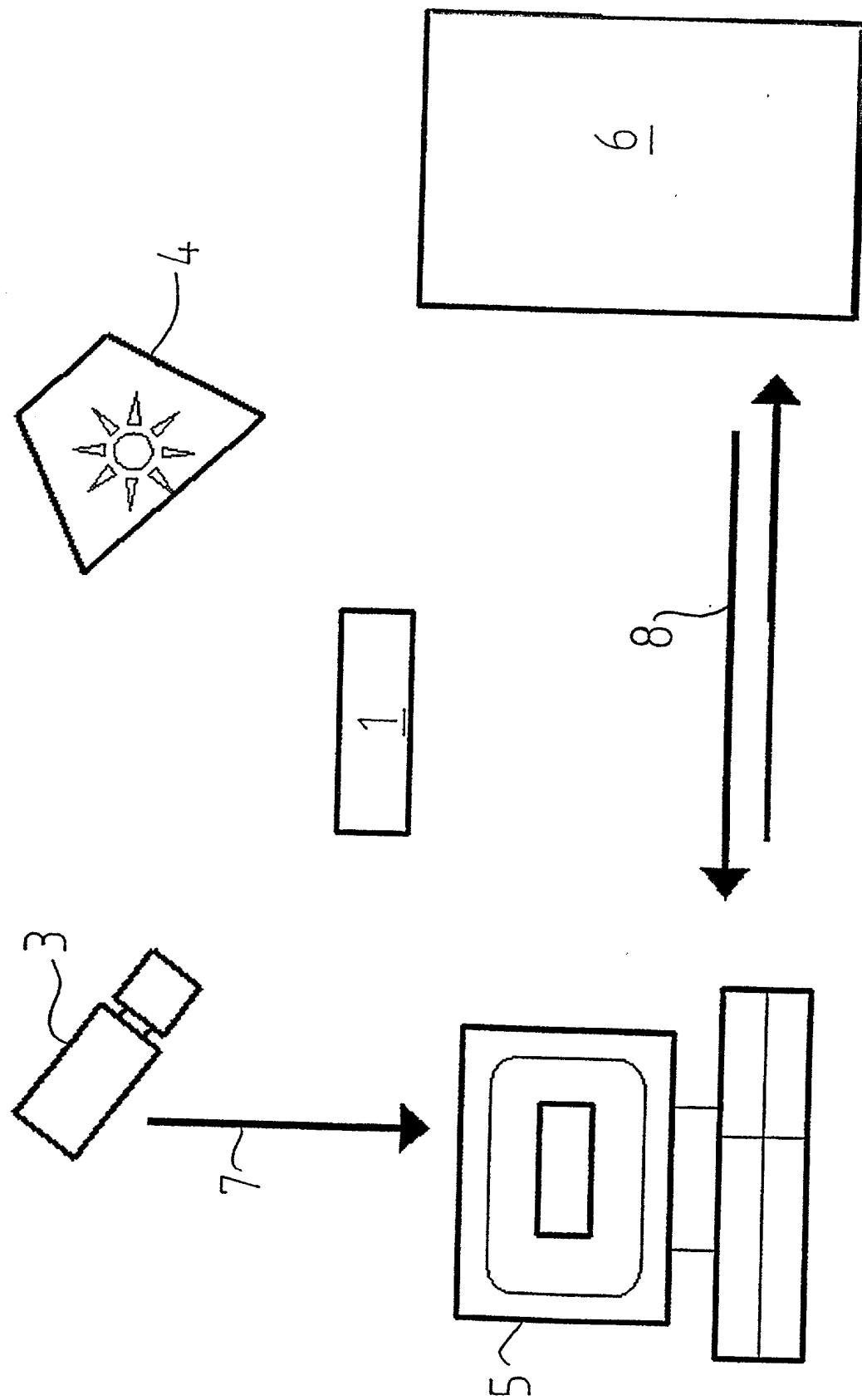


Fig. 2

## Declaration and Power of Attorney for Patent Application

### Erklärung für Patentanmeldungen mit Vollmacht

#### German Language Declaration

Als nachstehend benannter Erfinder erkläre ich hiermit an  
Eides Statt:

daß mein Wohnsitz, meine Postanschrift und meine  
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As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as  
stated next to my name.

I believe I am the original, first and sole inventor (if only  
one name is listed below) or an original, first and joint  
inventor (if plural names are listed below) of the subject  
matter which is claimed and for which a patent is sought on  
the invention entitled

#### METHOD AND DEVICE FOR OBJECT RECOGNITION

the specification of which is attached hereto unless the  
following box is checked:

was filed on 21 December 1999  
as United States Application Number or PCT  
International Application Number PCT/DE99/04070  
\_\_\_\_\_ and was amended on  
\_\_\_\_\_ (if applicable).

I hereby state that I have reviewed and understand the  
contents of the above identified specification, including the  
claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is  
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I hereby claim foreign priority under Title 35, United States Code, § 119(a)-(d) or § 365(b) of any foreign application(s) for patent or inventor's certificate, or § 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed.

**Prior Foreign Applications**  
(Frühere ausländische Anmeldungen)

**Priority Not Claimed**  
Priorität nicht beansprucht

<u>198 60 309.6</u>	<u>DE</u>
<u>Number</u> ( <u>Nummer</u> )	<u>(Country)</u> <u>(Land)</u>

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Ich beanspruche hiermit Prioritätsvorteile unter Title 35, US-Code, § 119(e) aller US-Hilfsanmeldungen wie unten aufgezählt.

<u>(Application No.)</u> ( <u>Aktenzeichen</u> )	<u>(Filing Date)</u> <u>(Anmeldetag)</u>
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<u>(Application No.)</u> ( <u>Aktenzeichen</u> )	<u>(Filing Date)</u> <u>(Anmeldetag)</u>
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<u>(Application No.)</u> ( <u>Aktenzeichen</u> )	<u>(Filing Date)</u> <u>(Anmeldetag)</u>
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Ich erkläre hiermit, daß alle in der vorliegenden Erklärung von mir gemachten Angaben nach bestem Wissen und Gewissen der Wahrheit entsprechen, und ferner daß ich diese eidesstattliche Erklärung in Kenntnis dessen ablege, daß wissentlich und vorsätzlich falsche Angaben oder dergleichen gemäß § 1001, Title 18 des US-Code strafbar sind und mit Geldstrafe und/oder Gefängnis bestraft werden können und daß derartige wissentlich und vorsätzlich falsche Angaben die Rechtswirksamkeit der vorliegenden Patentanmeldung oder eines aufgrund deren erteilten Patentes gefährden können.

21 December 1998

(Day/Month/Year Filed)  
(Tag/Monat/Jahr der Anmeldung)

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(Tag/Monat/Jahr der Anmeldung)

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<u>(Status) (patented, pending, abandoned)</u>
<u>(Status) (patentiert, schwebend, aufgegeben)</u>

<u>(Status) (patented, pending, abandoned)</u>
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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements we made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

**German Language Declaration**

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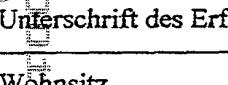
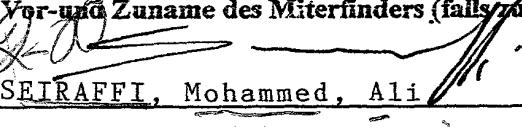
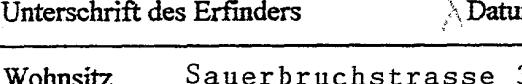
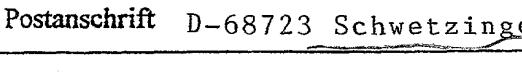
Telefonische Auskünfte: (Name and Telefonnummer)

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) to prosecute this application and transact all business in the Patent and Trademark office connected therewith: (list name and registration number)

Charles B. Elderkin  
Reg. No. 24,357 and all attorneys registered with Customer Number 000826

Send Correspondence to:  
Customer No. 000826  
Attn: Charles B. Elderkin

Direct Telephone Calls to: (name and telephone number)  
Charles B. Elderkin  
(704) 331-6000

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Vor- und Zuname des Miterfinders (falls zutreffend)  SEIRAFFI, Mohammed, Ali	
Unterschrift des Erfinders 	Date
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Staatsangehörigkeit Iran Deutsch	Citizenship
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CLT01/4381274v1

(Supply similar information and signature for third and subsequent joint inventors.)